lated experiments by scattered workers. This is one of the uses of the Poison Exponent, but it is likely that others would develop. For instance, the statement of a reputable manufacturer that his new preparation has a Poison Exponent of .75 to the most resistant instar of the boll worm would doubtless convey in the course of time a more definite idea to the mind of the entomologist than would a chemical analysis, valuable though the latter might be.

Whether the Poison Exponent is ever used or not, however, the writer cannot but believe that the subject of toxic values of chemicals to insects is a matter that is worthy of some consideration, and he hopes that other workers will give it the attention it deserves.

NOTES ON INSECT DESTRUCTION OF FIRE-KILLED TIMBER IN THE BLACK HILLS OF SOUTH DAKOTA

By Philip L. Buttrick, *New Haven, Conn.*

This paper attempts to outline the results of the work of insects following forest fires in the Black Hills of South Dakota; and to suggest remedies for their depredations. It is the result of casual observations of the writer, made while Forest Assistant on the Black Hills National Forest in 1911, and later as Forester for the Lanphere-Hinrich Company, a lumber company operating in the Black Hills. The observations do not pretend to approach completeness; but may be of some value in the absence of more definite data.

Character of the Forest in the Black Hills. Western Yellow Pine (*Pinus ponderosa*) is the predominant tree. It occurs pure over large areas, being the only commercial tree found. The forest tends to be even-aged in groups, but many stands are all-aged or roughly two-storied. The Government manages its holdings by a rough application of the shelter-wood system, the intention being to come back in twenty to thirty years for the second cut.

Enemies of the Yellow Pine. Forests in the Hills have suffered excessively from insects and fire. The chief insect enemy, the Black Hills Beetle[1] is too well known to require description. Its depredations have now been controlled by natural agencies, and by cutting large bodies of infested timber. A close watch is now kept by the

[1] *Dendroctonus ponderosæ* Hopk.

Forest Officers for all signs of beetle infestation, and all infested trees are at once cut and the bark destroyed.

A leaf scale, probably *Chionaspis pinifoliæ*, occurs, chiefly on seedlings and saplings. Its attacks are sometimes fatal. However, so long as it is not more abundant it need not be regarded as dangerous; perhaps it is slightly beneficial, since it usually occurs in dense overstocked thickets of young growth, where a thinning is badly needed.

The dry climate and the character of the forest operate to render fires numerous and severe, especially so in young growth where they often burn into the crowns. In old stands, particularly if there is no reproduction on the ground, they are confined to the surface and do less harm. Fires burning through irregular stands where the flames mount into the tops of the smaller trees, kill most of the stand but destroy little timber.

Destruction of Fire-Killed Timber. As a result of fires many thousands of feet of otherwise merchantable timber are killed annually. Much of this is never used. A knowledge of the rate of its subsequent destruction and methods of preventing it would result in saving much of it, thus reducing the drain on the live timber of the region.

Both insects and fungi attack trees killed by fire, their attacks being to some degree interrelated.

Fungi. Von Schrenk has given an account of two important fungi attacking beetle-killed trees, and they are also found on trees killed by fire. One, the "blue" fungus (*Ceratostomella pilifera* Winter), speedily stains the sapwood; the other, the Red-Rot (*Polyporus ponderosa* von Schrenk), follows after a longer interval, and causes the wood to decay. Other fungi attack live trees, but are not important here.

Insects. The chief insects infesting dead timber are, in the Black Hills, ambrosia beetles and the larvæ of Cerambycid and Buprestid beetles.

Hopkins lists two ambrosia beetles, *Gnathotricus sulcatus* LeConte, and *G. occidentalis* Hopkins, as occurring on beetle infested pine in the Black Hills. It is probable that these are the forms which occur on fire-injured and killed trees. Their attacks seem more apt to be directed towards injured than dead trees.

Ambrosia beetles bore in sapwood and to a less extent in heartwood. They cultivate a fungus in their burrows which stains the adjacent wood. These burrows also serve as a means for the extension of the "blue" fungus. The seasonal history for the species in the Black Hills has not been worked out in detail. The adults, however, seem to fly throughout the growing season, and to hibernate in their burrows

during the winter, several generations are doubtlessly produced in a season.

More important than the ambrosia beetles are the deep-wood borers, —the Cerambycid and Buprestid beetles,—whose larvæ make large burrows deep into the wood.

The destructive "Sawyer" (*Monohammus titillator*) of the Southern States seems not to be present in the Black Hills. The chief damage is done by the larva of a Buprestid beetle, probably the Heartwood Pine Borer (*Chalcophora virginiensis*) or one of its western forms *oregonensis*, or *angulicollis montana*. The three forms mentioned do not differ materially. All are large metallic lustered, bronze colored beetles, about an inch long and a quarter of an inch wide. They fly with a distinct buzzing sound.

The larvæ are elongated, whitish, flatheaded, legless grubs. The head is yellowish to brownish, and armed with strong jaws, which can be heard as it excavates in its burrow. The length at maturity is an inch and a half or more.

The adults fly in July, during the third week of that month the woods are full of them, but by the end of the first week in August all seem to have disappeared. The flying season probably lasts from the middle of June to the last of August at the outside.

The eggs are layed in holes cut in the bark by the female, occasionally in living, more often on recently dead trees. They hatch in a few days, and for a few weeks bore in the bark. Under favorable circumstances they may enter the wood within a month; by the end of two months, if conditions are favorable, they may have bored into it for two inches. The larval stage lasts till the following season, and may last for two years. Their activity does not continue after cold weather sets in, and the wood freezes.

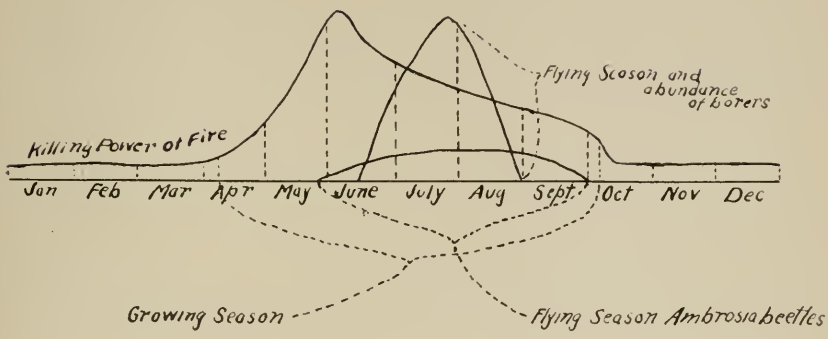
Character of Insect Damage. Ambrosia beetles aid in bluing fire-killed timber, but it is seldom that the sapwood escapes bluing even without their assistance. If timber is cut before it is badly infested by the larger borers, the work of the ambrosia beetles is usually removed with the slabs.

The larger borers if abundant will in time completely riddle a log, so that it is worthless save as firewood. In a single season they may reduce its value from thirty to fifty percent.

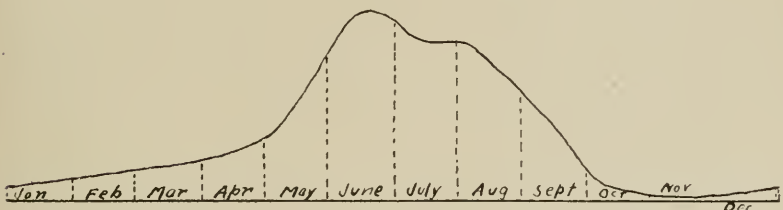
Effect of the Season of the Fire. The severity of attack by boring insects varies with the season of the fire. It can of course take place immediately after one only during the season when the adults are flying. The further removed from this period the fire comes the less will be the strength of the beetle attack, since the wood has more chance to dry out and the bark to become detached.

Plate 14

CURVE I.

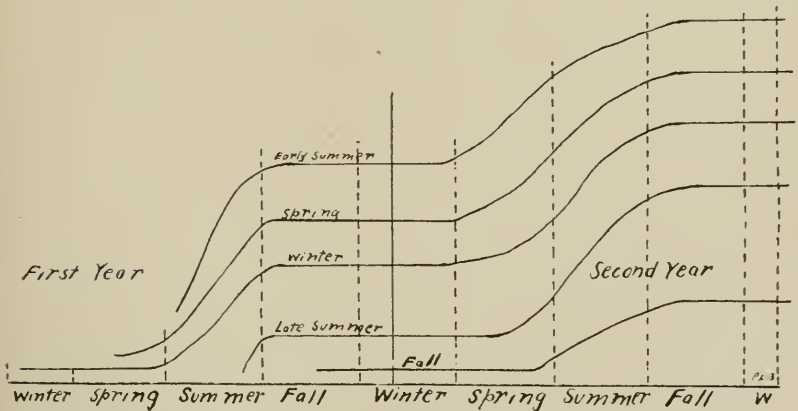


CURVE II



Degree of infestation following fires at different seasons

CURVE III



Probable rate of destruction by borers of timber killed at different seasons

The optimum conditions for attack seem to be following fires occurring early in the growing season. At such times the killing power of fire is at its highest. The moist condition of the wood causes fermentation and a rise of temperature. This favors the rapid growth of the larvæ, giving them time to become well established before seasoning of the wood and cold weather interferes.

On a large area burned about the middle of June, infestation by the last of August was so severe that the ground under the trees was white with the dust from the borings, which could be seen drifting to the ground like a light snow. The gnawing of the larvæ sounded like the croaking of innumerable frogs. An area close by burned in March was much less severely infested.

Rate of Destruction. Foresters and lumbermen in the Black Hills recognize the fact that fire-killed timber is generally worthless after it has stood two years. The relation of the season of the fire to the rate of destruction is not so well understood.

Timber killed just before the flying season will be practically worthless in fifteen months, or by the following fall, while timber killed after the growing season may not be as badly riddled after two years and a half. A close study of the rate of destruction would be of great value.

An attempt is made to express some of the facts regarding infestation and destruction graphically. The curves shown are for the most part relative as we do not possess sufficient data to make them entirely specific. The table derived partly from Curve III., would, if accurately worked up, be of value, by showing the time necessary to effect the injury and destruction of timber killed at different seasons.

Influence of Site on Severity of Attack. Wood borers prefer moist wood, and are therefore most frequent in localities where the wood is damp, such as in canyons, on steep north slopes etc., where there is protection from the sun and winds. On the tops of ridges exposed to wind and sun timber seasons quickly, and infestation is therefore often slight. The writer has examined timber from such localities that was unaffected by borers although it had been dead for several seasons. The proximity of a burned to an infested area is favorable for the spread of the pests.

These facts should be kept in mind in projecting a cutting in a recently burned area to prevent infestation. Timber in damp situations and that near infested areas should be removed or barked first.

Natural Checks. The large amount of dead timber scattered through the Black Hills as a result of the beetle invasion and the numerous fires have given a splendid and not neglected opportunity for wood borers.

It is probable that the pure character of the forest acts in their favor, the same as it does with other insect pests.

Woodpeckers eat many beetle larvæ, and are apt to congregate in burned areas where they are numerous. The Hairy Woodpecker is quite common and is the chief bird enemy of the Buprestid larvæ. Early in September the writer observed many at work in an area burned in June. They seemed to confine their attentions largely to the smaller trees, mostly the saplings fifteen to twenty-five feet high. They dug an inch or more into the wood for the grubs. Other woodpeckers occur in the Hills, but were not observed eating larvæ on recently killed trees. Probably Chickadees and Nuthatches eat the eggs and small grubs before they enter the wood, but are not able to dig into it after them.

Birds seem to serve more in keeping down the numbers of the pests than in saving timber already infested, since after borers are two or three inches into the wood only the larger woodpeckers can reach them, and then only when the wood is partly decayed.

Remedies. The obvious remedy for the destruction of fire-killed timber is of course to prevent fires. This attempt is made on the National Forests and the more valuable private holdings; but, like fires in cities, some forest fires will always occur despite all precautions.

The next best thing is to harvest the burned timber at once. This is often impossible, since it takes time to effect a timber sale on a National Forest, even when a purchaser is at hand. When roads and camps must be built it may require several months to prepare for cutting. If a fire occurs between June first and August fifteenth, it is almost impossible to get at the timber before infestation commences, much less remove any large bodies of it. However, if it can be cut and sawed within six weeks little damage would be done since the borers would still be near the surface, and would be removed with the slabs.

If timber is killed after the middle of August, there is a longer time for safe removal, although it will be attacked by ambrosia beetles and the bluing fungus till the coming of heavy frosts.

Lumbermen frequently want to know how to prevent the destruction of dead material without at once removing it. It is often proposed to cut and bark it, removing it to the mill at a more convenient season. This if carefully done is effective, but more costly than might be supposed. Barking costs about fifty cents per M feet B. M., which is half as much as felling itself costs. There would be no profit in barking small top logs, since it does not pay to handle these except under the best of conditions. It is doubtful if any large amount of timber could be kept from bluing by this method.

If logs are badly infested and the larvæ are well into the wood, it is doubtful if merely barking them would destroy the pests. In such cases it would be better to build skidways in the open above the surface and pile the logs onto them in such a way that the air could get at them from all sides, so as to facilitate seasoning. Care should be taken not to deck them up in tiers, as this interferes with seasoning. Such a method would be more expensive than letting the logs lie on the ground; but would tend to prevent bluing, and would probably kill all borers.

Another remedy often proposed is to cut dead or infested material and immerse it. This not only prevents all infestation, but kills all larvæ already in the wood, and prevents fungus attacks. It is not suitable in the Black Hills, since no natural ponds exist, and the cost of building dams large enough for the storage of large quantities of logs is prohibitive. The running of infested material through a log pond to kill the borers has been suggested. This works if the logs are in the water long enough. The writer has noticed that good sized logs after remaining in the pond at the Lanphere-Hinrich mill for two or three days had live borers at their centers when sawed. Logs would have to remain in the pond until they were thoroughly soaked out, perhaps a week or more, rendering the process slow, and perhaps not possible for any large amount of timber.

If a systematic attempt were made to apply this method, it might be well to experiment with poisonous solutions in the water, such as copper sulphate or mercuric chloride. These might shorten the time necessary for immersion, and would tend to prevent reinfestation, or fungus attacks.

Uses for Infested Material. A lumberman frequently finds himself in possession of an amount of infested timber, which he does not wish to lose. What can he do with it?

It may of course be manufactured into common lumber and sold for what it will bring as "number two common." Or perhaps it may be disposed of as firewood. The demand for both of these is small, and no large amount of either can be marketed at one time, moreover the profit is small. For it costs as much to handle burned as green timber, and the price on the finished product is from a third to a half lower, in addition to a greater waste in manufacture.

Railroad ties are sometimes sawed from fire-killed timber, but are not very satisfactory. However, if they could be treated with a timber preservative, they would be more valuable in many cases than green ties. While the larger railroads in the Black Hills have treating plants, they draw their timber supplies mostly from elsewhere.

The establishment of a commmercial treating plant in the Black Hills would solve many of their problems of wood utilization.

The use of untreated infested material for mine timbers is not usually advisable, since the moist conditions prevailing in most mines allow the continued existence of both insects and fungi, which speedily destroy the timbers, necessitating frequent renewals.

A certain lumberman in the Black Hills has solved for himself the problem of the use of fire-killed and infested timber, by turning it into box boards. There is a large and steady demand throughout the Middle West for them by the large meat packing companies. He has no difficulty in disposing of any fire-killed material, no matter how much blued or infested, so long as it is not affected with red-rot.

This solution of the difficulty is not at the disposal of the small man with a portable mill, for it requires a special outfit to saw the match box boards. He might in some cases sell his burned material to a box mill after sawing it out in the rough.

Summary. Destruction of fire-killed timber is largely accomplished by Buprestid beetles, whose larvæ riddle it. In from fifteen months to two years and a half they, in combination with fungi, entirely destroy it for commercial purposes.

The rate of damage varies with the locality of the timber and the season of the fire, being at its maximum in moist localities, following fires in the early part of the growing season.

Remedies. Prevent fires, cut and remove fire-killed timber at once, if this is not possible, bark burned and infested trees and place them on skidways to season. Ponding is the best remedy, but is not generally possible. Running of infested logs through a log pond would destroy borers if the logs were left in long enough. The use of poisonous solutions in the water should be tried.

Infested material can be used in small amounts for low grade products, and for box boards; but often it will not pay to handle it.

TABLE I.

PRELIMINARY TABLE SHOWING RATE OF DESTRUCTION OF FIRE KILLED TIMBER.

Season of Fire	Infested	Partially destroyed	Entirely destroyed
Spring	In a few months	That fall	Following fall
Early Summer	Immediately	That fall	Following fall
Late Summer	Partially at once; fully following season	Following fall	Two years
Fall	Following Summer	Following fall	Two–three yrs.
Winter	Following Summer	Following fall	Two–three yrs.

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NOTES OF THE SEASON FROM CONNECTICUT

By W. E. Britton, *Agricultural Experiment Station, New Haven, Conn.*

During the year some interesting and rather important investigations have been conducted by this department. In Connecticut the walnut weevil, *Conotrachelus juglandis* Lec., has been so destructive that for several years it has been nearly impossible to obtain fruit of the various imported and cultivated walnuts belonging to the genus *Juglans*.

In nearly all of the scanty literature this weevil is said to breed in the nuts, but in Connecticut, the larvæ do much greater damage by tunneling in the new shoots, causing them to wither and die before they can produce fruit. My assistant, Mr. H. B. Kirk, has worked out the life history of *C. juglandis* the past summer. Very little has heretofore been known regarding it. A bud moth, *Acrobasis* sp., also attacks and injures the new growth and Mr. Kirk has studied this insect, finding three generations each season.

Though these studies represent only one season's work, the results indicate that both the weevil and the bud moth can be controlled by spraying the foliage and shoots with lead arsenate. A complete account of the work mentioned above, including bibliography, and distribution of the walnut weevil in the United States will appear during the winter in the next report of the Station (12th Report of the State Entomologist of Connecticut).

For three years Mr. B. H. Walden has been making observations upon a sawfly found defoliating cultivated blackberries in a field near New Haven. A knowledge of its life history is now complete and the insect being a new species of the genus *Pamphilius* was described by Prof. A. D. MacGillivray in *Canadian Entomologist*, Vol. XLIV, October,